

## INF2178 A4 - Exploring MRI Results Using Mixed-Effects ANOVA

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### Introduction & Research Question

For the purpose of this project, we are interested in exploring a subset of data of a longitudinal study on MRI results of patients with or without dementia and other potential influencing factors. We will be using “nWBC” and “ASF” as our outcome variable, as the whole brain volume and Atlas Scaling Factor are two good representations of the MRI results.

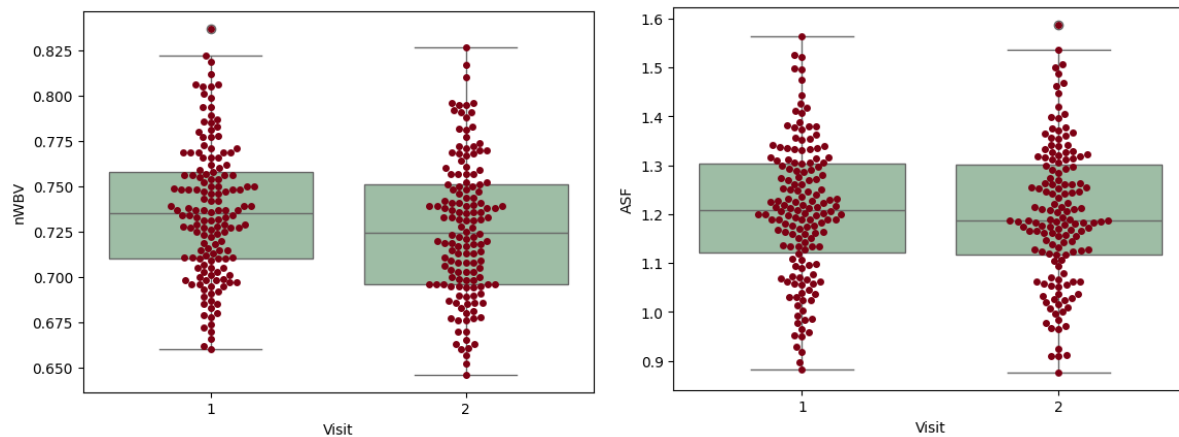
The subset includes both cross-sectional and time-series data, and we will be using mixed-effects ANOVA to examine the following questions:

1. Does the “Group” factor (i.e. Demented, nondemented, converted) have a significant impact on the MRI results between the first and second visit?
2. Does different gender have a significant impact on the MRI results between the first and second visit?

### Exploratory Data Analysis (EDA)

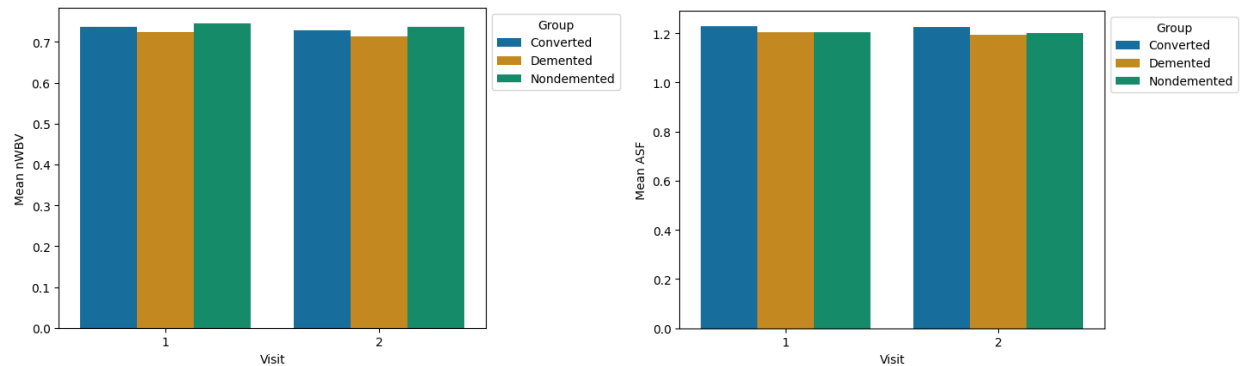
Before conducting statistical tests, we are first interested in exploring some visualizations of the dataset to have a general idea of the distribution of patterns.

First, we create boxplots along with swarmplots to compare the distribution of nWBV and ASF between the first and second visit.



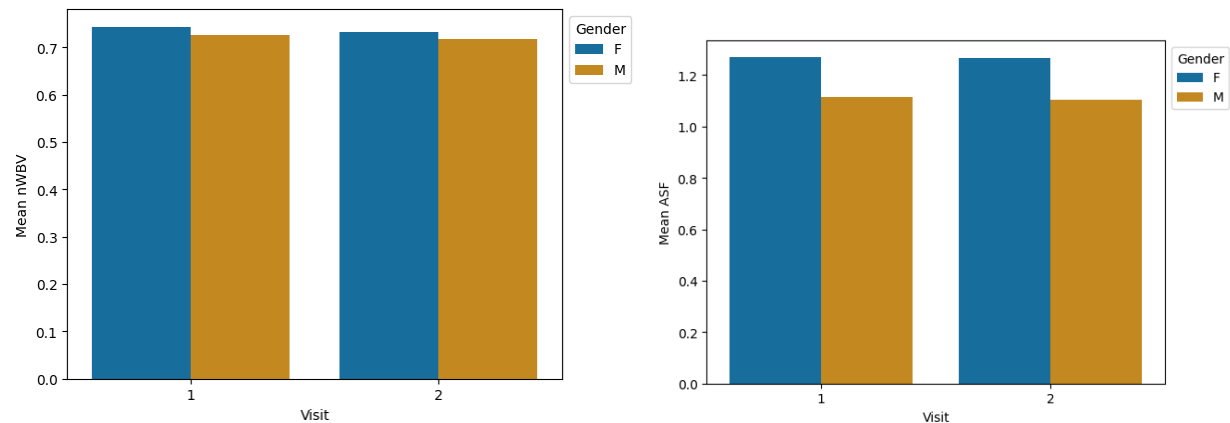
nWBV and ASF are two factors that can be used to represent the MRI outcomes. We would like to compare them horizontally to see if similar trends can be observed. Overall speaking, the two graphs look similar. However, nWBV score exhibits outliers in the first visit where as the ASF score exhibits outliers in the second visit. This may potentially mean that two outcome scores provide different results. Further analysis is needed.

Then we use barplots to see how different groups (i.e. Converted, demented, nondemented) demonstrates different outcomes respect to two visits.



No clear distinctions can be found on barplots. We cannot conclude anything just by looking the diagrams that just generated with respect to different groups.

Then we conduct a similar barplots, but this time we are using gender as the differentiating factor.



We are able to see that for the mean nWBV score, both the gender and the visit time do not demonstrate a big difference. On the other hand, female seems to generally have a higher score of ASF than male despite the visit time. This is interesting and we would like to explore further.

### First Research Question

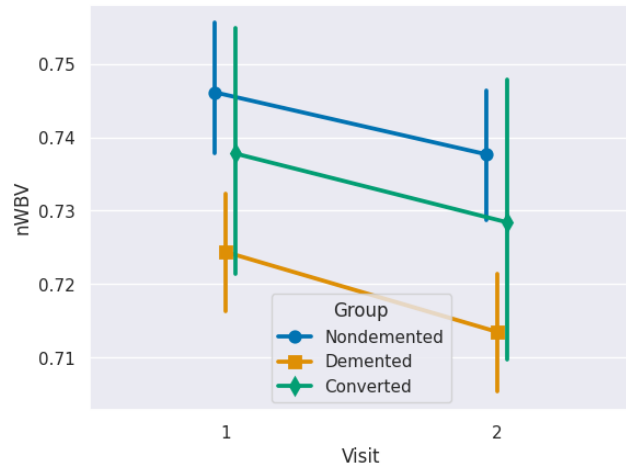
Recall our first research question: *Does the “Group” factor (i.e. Demented, nondemented, converted) have a significant impact on the MRI results between the first and second visit?*

We conduct mixed-effects ANOVA test and the results are the following:

Source	SS	DF1	DF2	MS	F	p-unc	Np2	eps
Group	0.034	2	141	0.017	6.712	0.002	0.087	NaN

Visit	0.007	1	141	0.007	94.251	< 0.001	0.401	1
Interaction	0.000	2	141	0.000	1.534	0.219	0.021	NaN

We also conduct a post-hoc test to see the interaction effect (Detailed post-hoc test output is not shown due to space limit, please refer to the Python notebook).



With such small p-value (i.e. lower than any significant level) in both the “Group” and the “Visit” row, we can say that there is significant difference in MRI results between the groups at different time of the visit. However, interaction effect is not significant since the p-value is over 0.2, we can also conclude the interaction effect is not significant via the post-hoc test and just by look at the graph on the left, no clear interaction among the three lines.

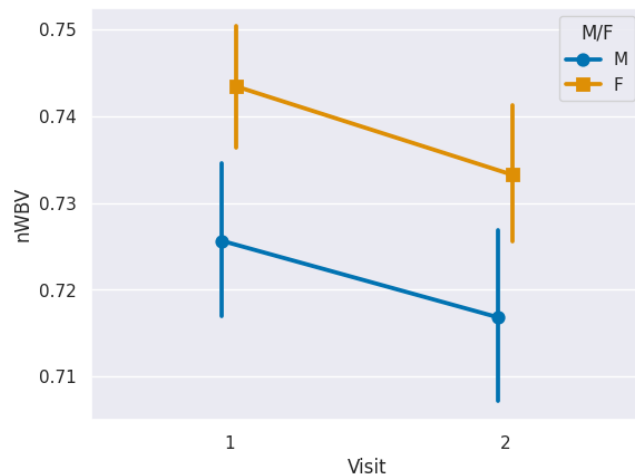
## Second Research Question

Recall our second research question: *Does different gender have a significant impact on the MRI results between the first and second visit?*

We run another mixed-effects ANOVA test and the results are shown:

Source	SS	DF1	DF2	MS	F	p-unc	np2	eps
M/F	0.021	1	142	0.021	8.030	0.005	0.054	NaN
Visit	0.007	1	142	0.007	93.305	< 0.001	0.397	1
Interaction	0.000	1	142	0.000	0.621	0.432	0.004	NaN

The additional post-hoc test is also conducted (Refer detailed output in Python notebook).



The p-value of the M/F and Visit factors are both smaller than any significant level. So we can say that there is distinct difference in the MRI outcomes between genders at different visit time. However, the interaction effect is not significant, we can conclude this by looking at the interaction term p-value, the post-hoc test, as well as the graph on the left, the two lines do not intersect each other.

## Assumptions Check

We conduct normality and homogeneity of variances assumptions check for both nWBV and ASF factor since we are using them as our outcome variables. The results are shown below:

Mixed-effects ANOVA test with nWBV outcome variable:

Visit	W	pval	normal
1	0.990	0.372	TRUE
2	0.989	0.367	TRUE

	W	pval	equal_var
levene	0.504	0.478	TRUE

Mixed-effects ANOVA test with ASF outcome variable:

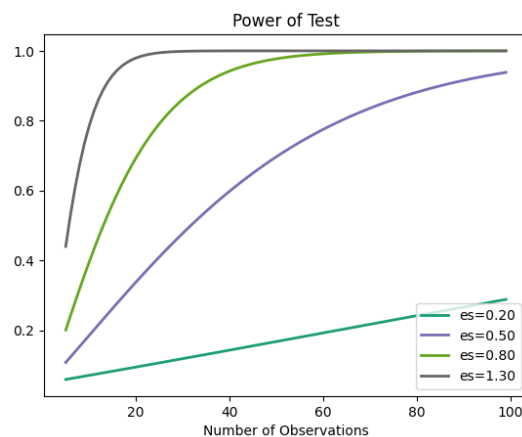
Visit	W	pval	normal
1	0.993	0.642	TRUE
2	0.993	0.699	TRUE

	W	pval	equal_var
levene	0.125	0.723	TRUE

Both results provide high p-values and have shown that normality and homogeneity of variance assumptions are not violated. The model is a good fit and the outcomes can be interpreted fairly.

## Statistical Power Analysis

Given the effect size of 0.7, an alpha level of 0.05, and a power of 0.91. The appropriate required sample size is approximately 45.45, which means the minimum sample size should be 46 in order to achieve the results. The dataset of this project has almost 300 observations, the greater sample size contributes to a more robust outcomes of the analysis. The power curve is shown in a diagram below as well to provide insights on the choice of effect size, power, and sample size.



## Conclusion

In conclusion, the dataset exhibits significant differences in the MRI outcomes (nWBV and ASF) between groups and between genders at two different time of visits. However, further exploration should be undertaken to reach a more robust conclusion after adjusting the equal sample size for the groups and the genders.